

What is claimed is:

1. In a plant made up of a plurality of automated stations for the performance of an assembly process for body parts or the like with there being in the stations automatic means for support and blocking of the parts to be assembled and automatic assembly means for the supported and blocked parts a method for identification and management of errors and defects comprises:

- a. preliminary analysis steps comprising the steps of:
 - determining measurement points sensitive to the movement of constraint points which comprise support and blocking points for the parts in the stations, and
 - determining correlations between measurements detectable in said measurement points sensitive to said movement and possible causes which might generate such movement;
- b. inline diagnostic steps comprising the steps of:
 - overseeing any movements in the previously identified measurement points and in this case tracing back to the possible causes of the movements, and
 - signaling such possible causes to allow their elimination if desired or necessary.

2. Method in accordance with claim 1 comprising the steps of:

- arranging sensors for measurement of geometric magnitudes of the parts in established reading points,
- realizing a mathematical structural model of the

parts assembled in the various stations,

- applying to the model a trial and error method comprising application to the model of a plurality of possible stresses and determining which among the plurality of stresses are those which give in the model deformations which approach most the deformations detected practically in the measurement points, and
- using the distribution of stresses thus identified to obtain the stress points which generated it in practice in order to supply a diagnosis of the defects or errors of assembly in the plant.

3. Method in accordance with claim 2 in which the mathematical model is a simplified model in which the nodes of the model are reduced to points of constraint and application of stresses comprising the points of support and blocking of the parts in the stations and to said points of reading.

4. Method in accordance with claim 2 in which from the distribution of stresses thus identified is taken one or more distributions of corrective stresses to be applied in the stations and intended to compensate for the deformations detected in practice in order to supply therapy for the defects or errors of assembly in the plant.

5. Method in accordance with claim 4 in which, if there are more distributions of stresses tending to compensate for the deformations, from among these is selected as distribution of stresses to be used in practice the one which optimizes previously identified parameters.

6. Method in accordance with claim 5 in which the

parameters to be optimized are chosen from among minimization of the residual deformations after correction, minimization of the number of corrective stresses to be used, minimization of the overall number of corrective stresses to be applied, and minimization of the internal tensions induced by the corrective stresses.

7. Method in accordance with claim 3 which for choice of the reading points comprises the steps of:

- using a structural model of the parts to ascertain zones defined by a series of points of sensitivity for each cause of stress or possible combinations of stresses it is desired to measure,
- distinguishing the zones defined in relation to the causes associated with them, and
- applying to the distinguished zones the trial-and-error method to define optimal measurement "zones" by positioning virtually the sensors in the zones previously distinguished and calculating the number of causes measurable so as to find in which positions the sensors measure the highest number of causes.

8. Method in accordance with claim 7 in which are simulated all the possible positionings of sensors and an optimal solution consisting of the complex of sensors which ensures maximization of the number of causes measurable and minimization of the number of sensors used.

9. Method in accordance with claim 4 which, to determine whether and to what degree the position of previously identified points of the assembled parts are sensitive to the movement of constraint points in a station before their

assembly, comprises the steps of:

- detecting the trend of the dispersal of the geometrical errors in said preascertained point before and after the assembly operation,
- 5 - examining the "correlation" and "linear regression line" between the input and output of said dispersal, and
- defining the preascertained point as the more "sensitive" as the correlation between input and output
- 10 is lower and the further the inclination of the linear regression line from 45°.

10. Method in accordance with claim 4 which to determine the amount of the movement of a constraint point to be imposed in a station to permanently change the position of

15 a preascertained point of parts assembled in the station comprises the steps of:

- measuring the trend of the dispersal of the geometrical errors in said preascertained point before and after the assembly operation,
- 20 - examining the "linear regression line" of said dispersal between input and output, and
- imposing on the constraint point a movement "s" equal to

$$s = y / (1 - m)$$

25 with x being the measurement at input, y the measurement at output and m the angular coefficient of the regression line.

11. Method in accordance with claim 4 which to trace points of the process responsible for errors and defects comprises

the steps of:

- calculating the typical trend of the systematic errors along the process which will be called "process signature",
- 5 - defining the ideal process signature termed "zero signature" which leads to having zero errors on the assembled part at the end of the process,
- receiving from the measurement sensors of the stations current dimensional data on the parts and
- 10 calculating therefrom the present process signature, and
- using the deviations of the present process signature from the zero signature to ascertain the process points responsible for errors and defects.

15 12. Method in accordance with claim 3 which to realize the geometrical reconstruction of the assembled part comprises the steps of:

- a. making congruent measurements taken in different stations on a same part by structural analysis and
- 20 "best fitting",
- b. taking from the measurements local shape data on parts to be assembled and extracting therefrom local shape error data,
- c. taking from the measurements general data on the
- 25 positioning geometry of the parts and taking them on the parts along the plant, and
- d. processing the local shape data and the general geometry data taken above and reconstructing the general geometry of the parts by structural analysis

using as starting geometrical data the local shape error data taken in step b above and as constraints the positioning data of the parts taken in step c.

13. Plant made up of a plurality of automatic stations
5 for the performance of an assembly process of body parts or the like with their being in the stations automatic support and blocking means for the parts to be assembled and automatic assembly means for the parts supported and blocked and comprising in the stations measurement
10 sensors in established measurement points for measurement of geometrical magnitudes of the parts in assembly with the measurement data taken by the sensors being received by a processing unit which takes any deformations of the parts in the various stations and goes back from the
15 detected deformations to the causes thereof in the assembly process and emits a diagnosis signal of the presumed cause.

14. Plant in accordance with claim 13 characterized in that in the processing unit is memorized a simplified
20 mathematical structural model of the parts assembled in the various stations in which the nodes of the models are reduced to points of constraint and application of stresses which comprise the support and blocking points of the parts in the stations and said measurement points with the
25 central unit applying to the model a plurality of possible stresses and determining which among the plurality of stresses are those which give in the model deformations which most approach the deformations detected by the sensors in practice.

15. Plant in accordance with claim 13 characterized in that in the stations there are means which can operate on its pieces in assembly to supply correction of the deformations detected.